Land Cover Satellite Project Science Office (LPSO):

Summary of Activities / Accomplishments

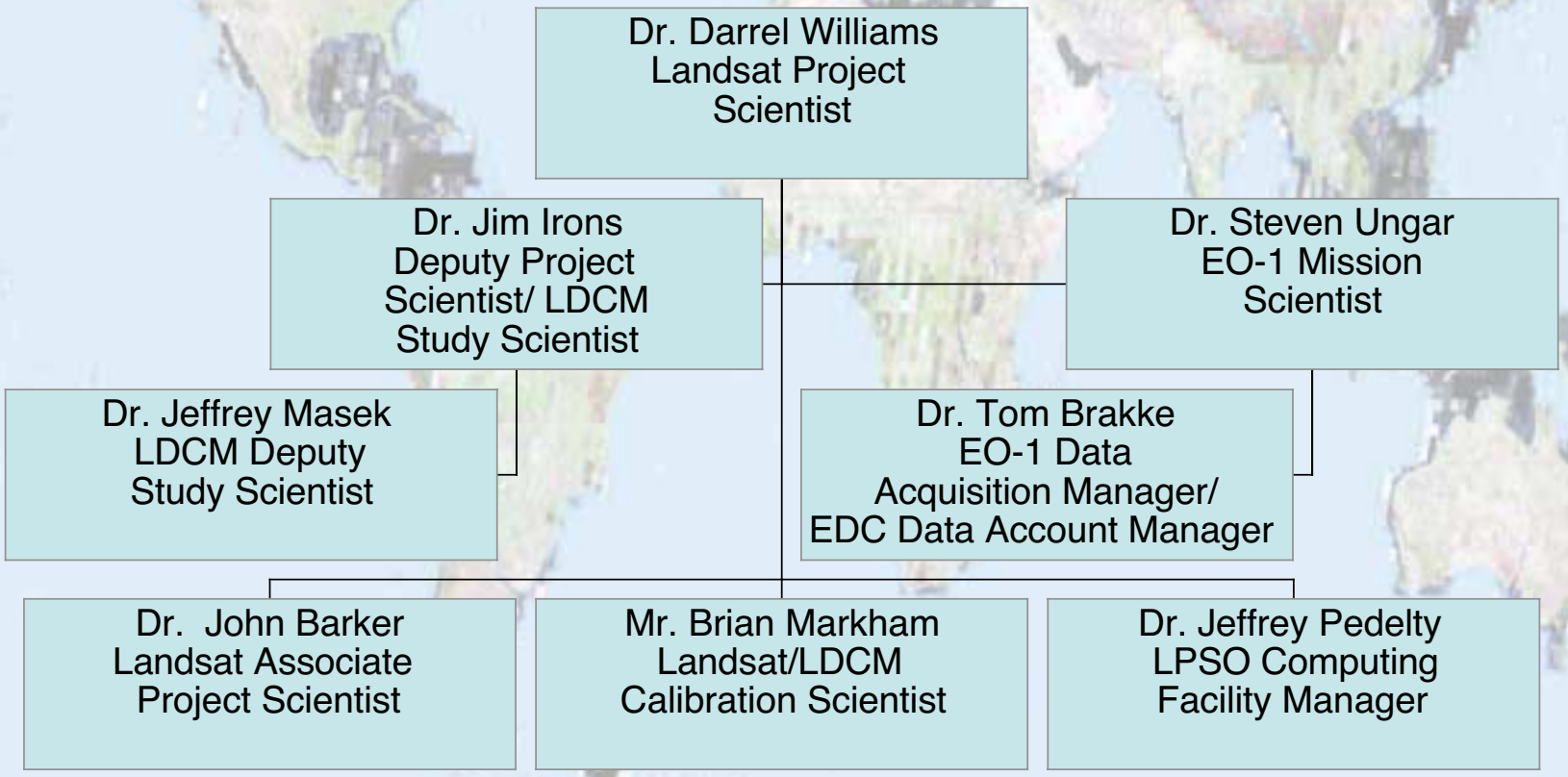
Darrel Williams

Presentation Objectives

- **Review of Science Office activities**
  - **1992 to present (who we are, our charter, review of some key accomplishments and activities, etc.)**
  - **Quick look at Landsat archive quality -- then and now**
  - **Efforts to develop "gap-fill" products**
  - **Data quality assessment update will be provided in Brian Markham's talk next**
- **Summary**
  - ***we constitute NASA's in-depth corporate memory for the past, present and future Landsat Program***

LPSO Background
"Who We Are"

Science Office - Civil Servants



The Landsat Mission

- The Landsat mission is to:
  - Acquire **well-calibrated,** moderate resolution, multispectral imagery affording **systematic global coverage** of the Earth's land surfaces on a **seasonal basis** and make the data readily available for **large-scale and long-term** Earth system science and land resource management

Comparison of the spatial / areal coverage of Landsat with other satellite systems

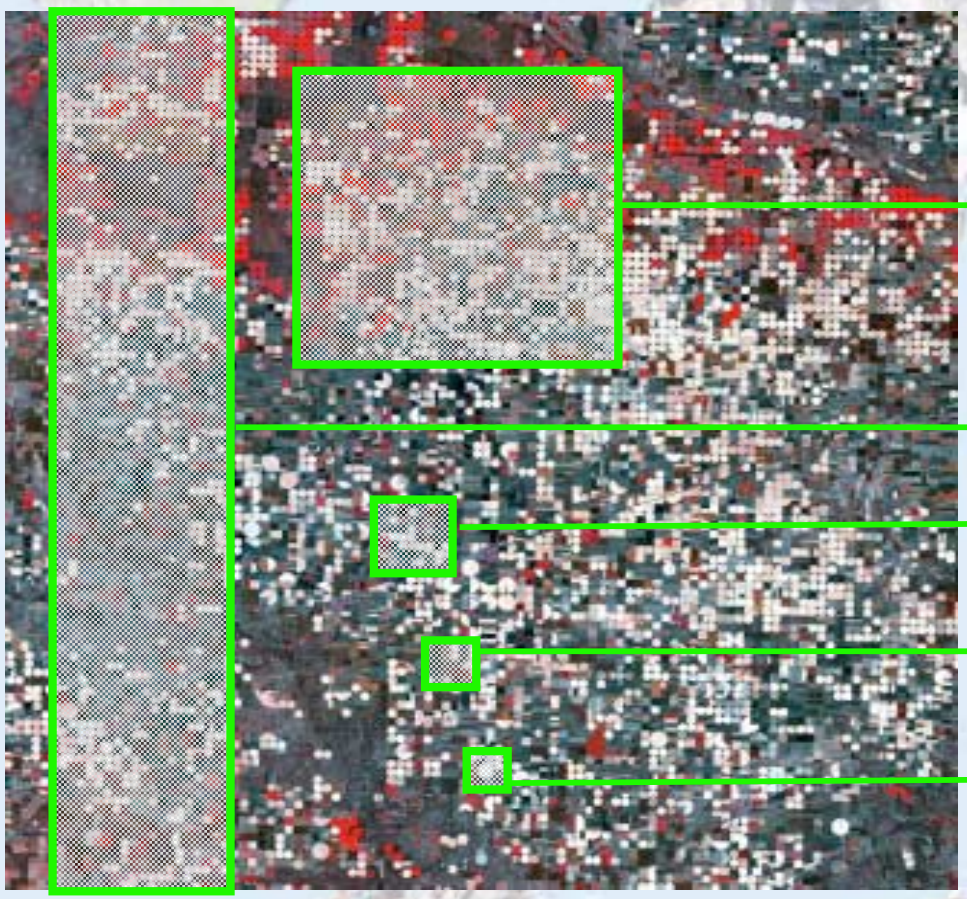


Illustration courtesy of USGS

Science Office Charter

- **Ensure scientific integrity of Landsat mission**
  - **Data acquisition (Long Term Acquisition Plan or LTAP)**
  - **Continuity (L5, L7, EO-1, LDCM)**
  - **Characterization / Calibration**
  - **Documentation (articles, Data Users Handbook, etc.)**
  - **Education / Public Outreach (visualizations, presentations, curricula development, etc.)**
- **Mission support (per NASA / USGS MOU)**
  - **Anomaly resolution [e.g., Scan Line Corrector (SLC) malfunction]**
  - **Sensor performance evaluation for Performance Evaluation Board (PEB) / fee determination**
  - **Image Assessment System (IAS) scientific oversight**

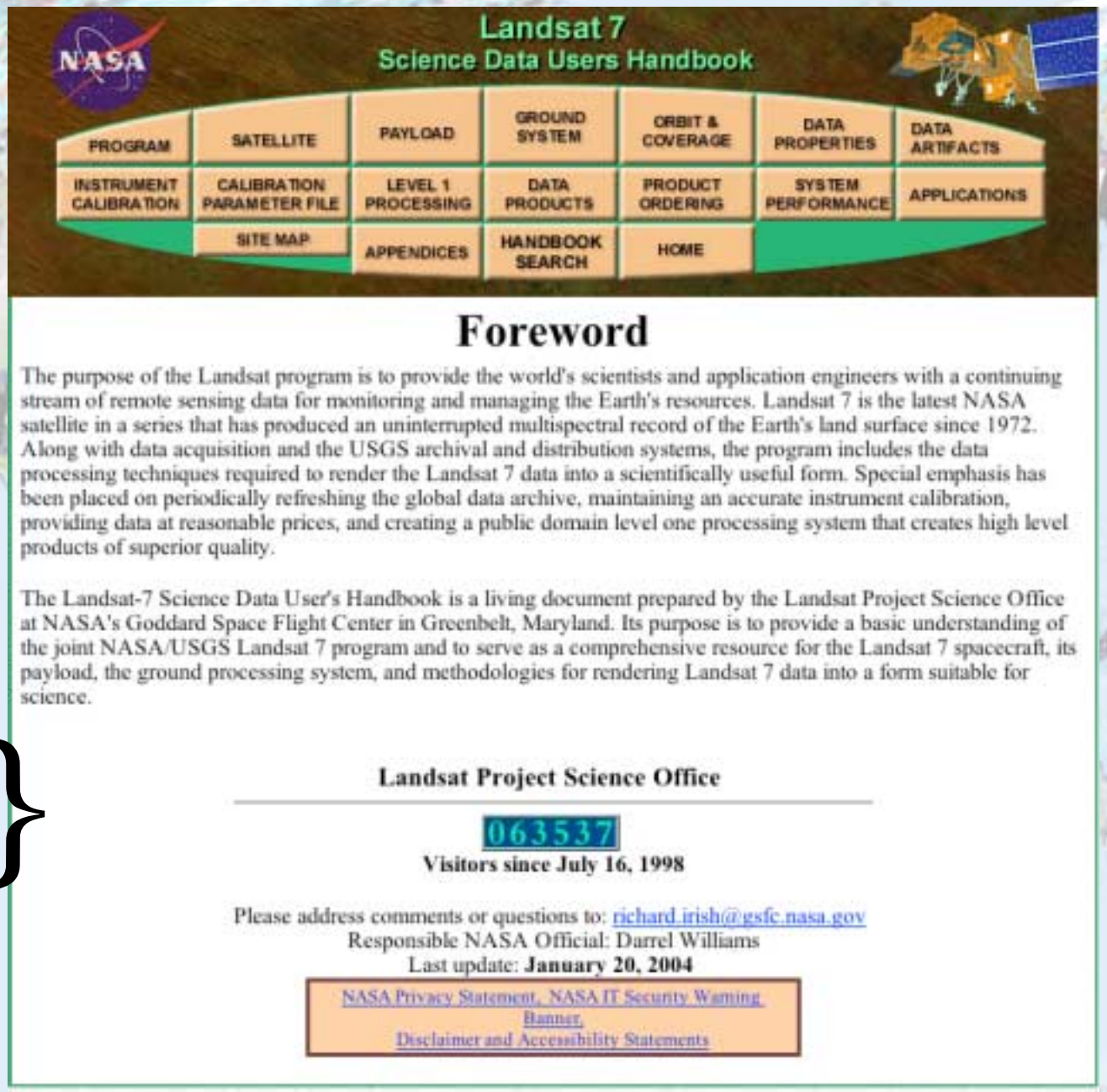
Key LPSO Accomplishments

(not it priority order)

- **Conceived the idea of the Image Assessment System (IAS); then oversaw its development**
- **Catalyst behind development of a Long Term Acquisition Plan (LTAP)**
  - **established 250 scenes per day benchmark; global seasonal refresh**
- **Conceived the idea of formation flying with Terra (along with Piers Sellers)**
- **Conceived the idea of underflying Landsat 5 with Landsat 7**
- **Fought to get Level 1 processing back into the program**
- **Helped sell idea of EO-1 ALI as a needed technical risk reduction pathfinder**
- **Wrote EOS-1/LandsatNext concept paper leading to LDCM (Landsat Data Continuity Mission)**
- **Designed/drove pre- & post-launch calibration procedures, making the ETM+ the "best of the best"**
- **Fought for placement of X-band antenna at EDC, ensuring direct downlink of lower 48 states**
- **Initiated educational / outreach activities (video's, web page's, curricula development, training)**
- **Found funds ($750K) needed for salvage of MSS wide band video archive (30,000+ scenes)**

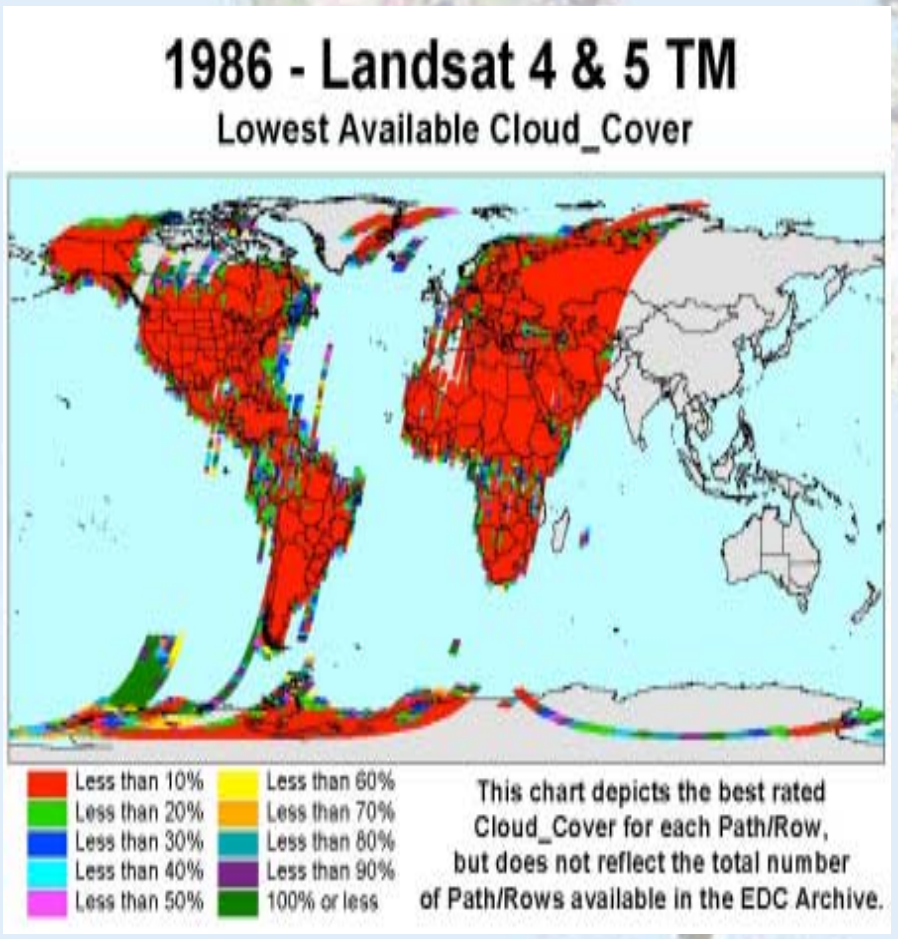
Continuing LPSO Objectives / Tasks

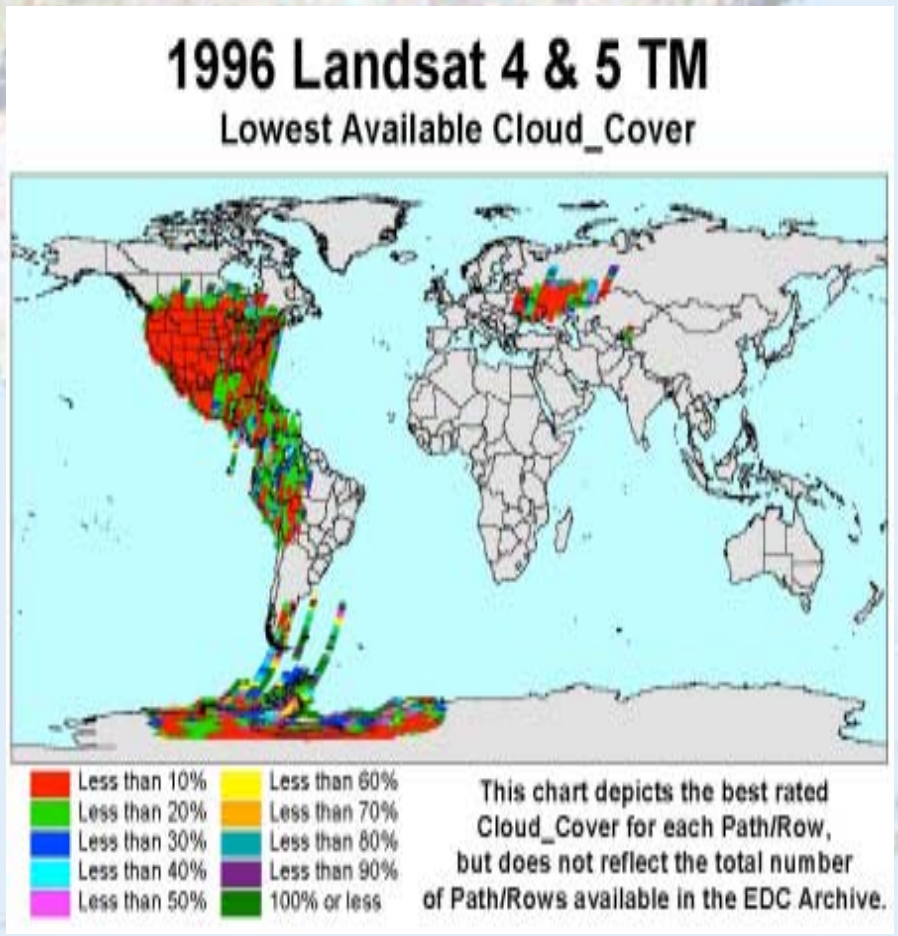
- **Help the USGS EDC operate the Landsat 7 system in a manner that fully supports the Earth Science Enterprise.**
  - **continue to provide the EDC with scientific support and technical advice**
  - **serve on the EDC Configuration Control Boards (CCB's)**
  - **serve as a resource for data and system anomaly resolution and trouble shooting**
- **Characterize, validate and document ETM+ on-orbit performance and data quality.**
  - **publish results in refereed journals and present results at symposia**
  - **continue to maintain a website providing real-time public access to results and test data**
  - **these data are used for Performance Evaluation Board award fee determination**
- **Develop, code, test and validate improved calibration algorithms and Level 1 data processing algorithms.**
- **Participate in vicarious calibration experiments with other EOS Instrument Teams for cross-calibration of multi-platform instruments.**



~ 63,500 "hits" as of March 11th, or ~ 30 hits per day.

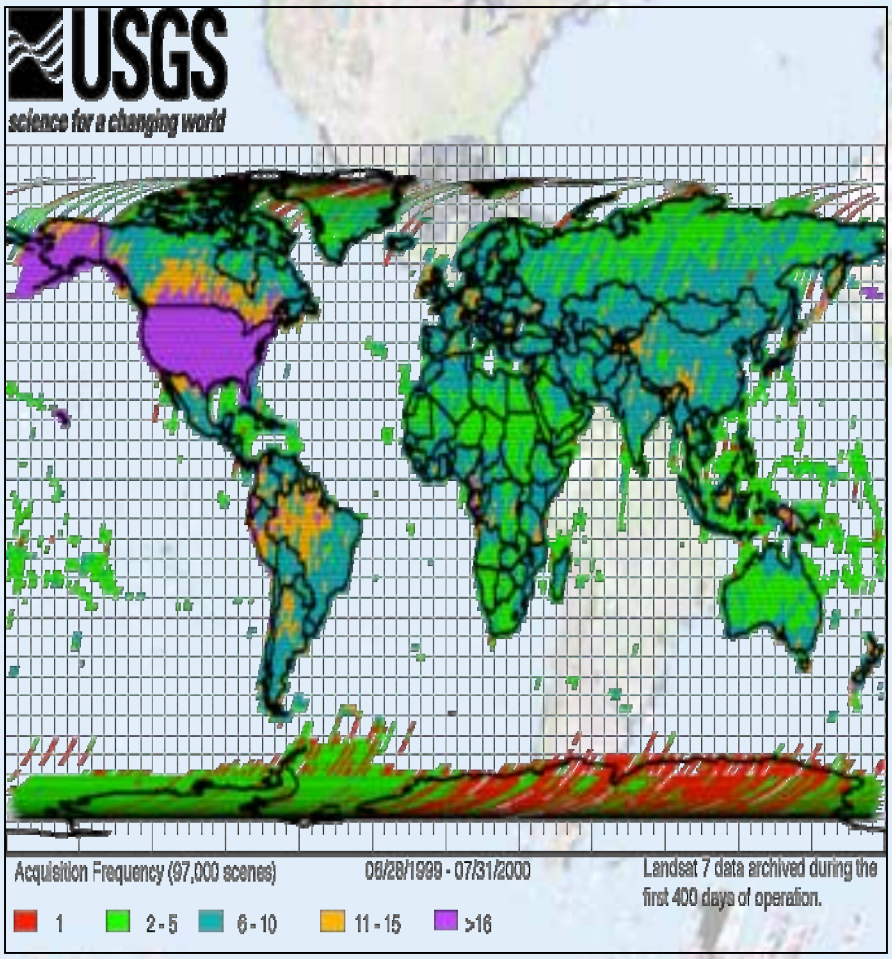
Landsat 4/5 Coverage
(1986 & 1996, J. Faundeen, NSLRSDA)

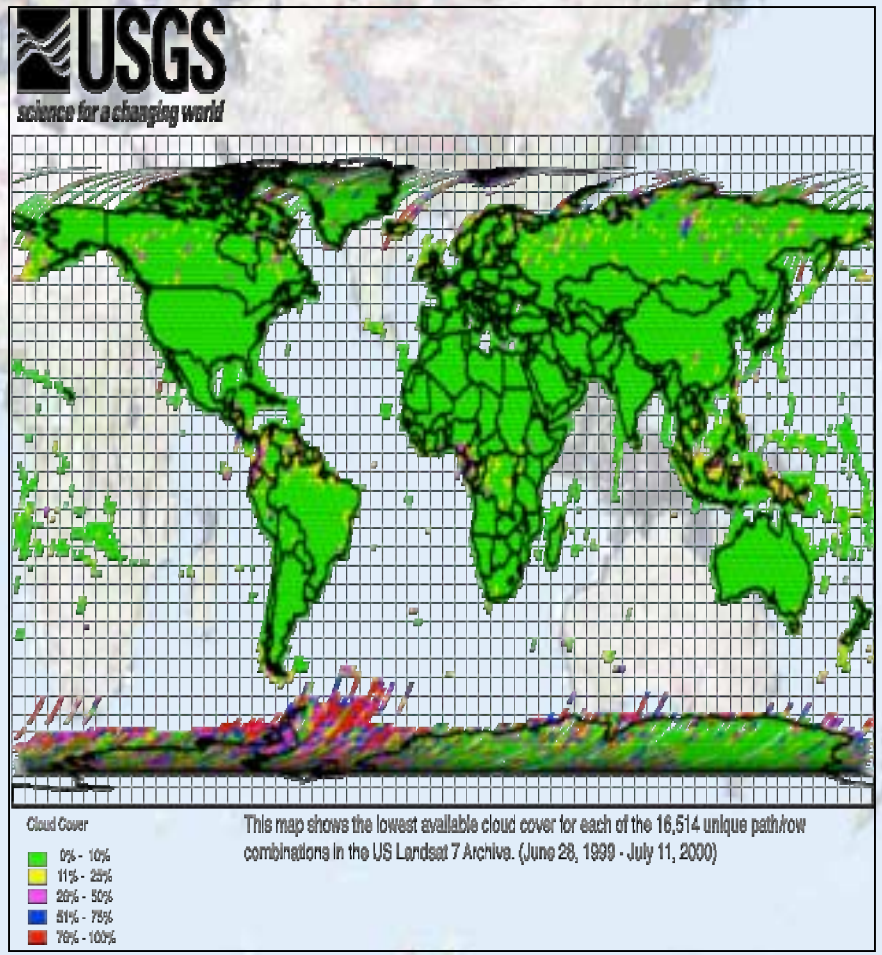




Concept of 20 years of TM global coverage is a myth!

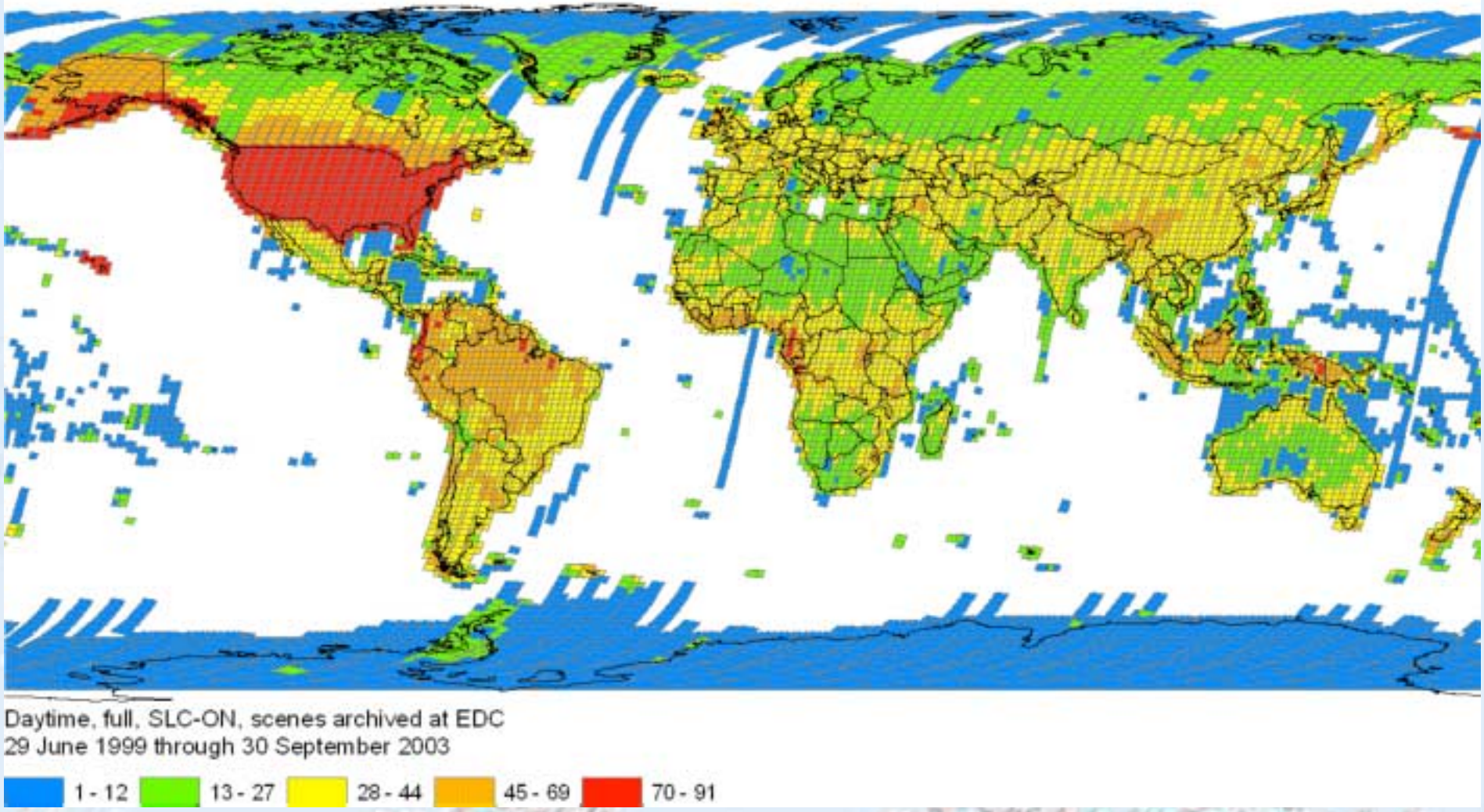
Landsat-7 First-Year Coverage
(with LTAP)



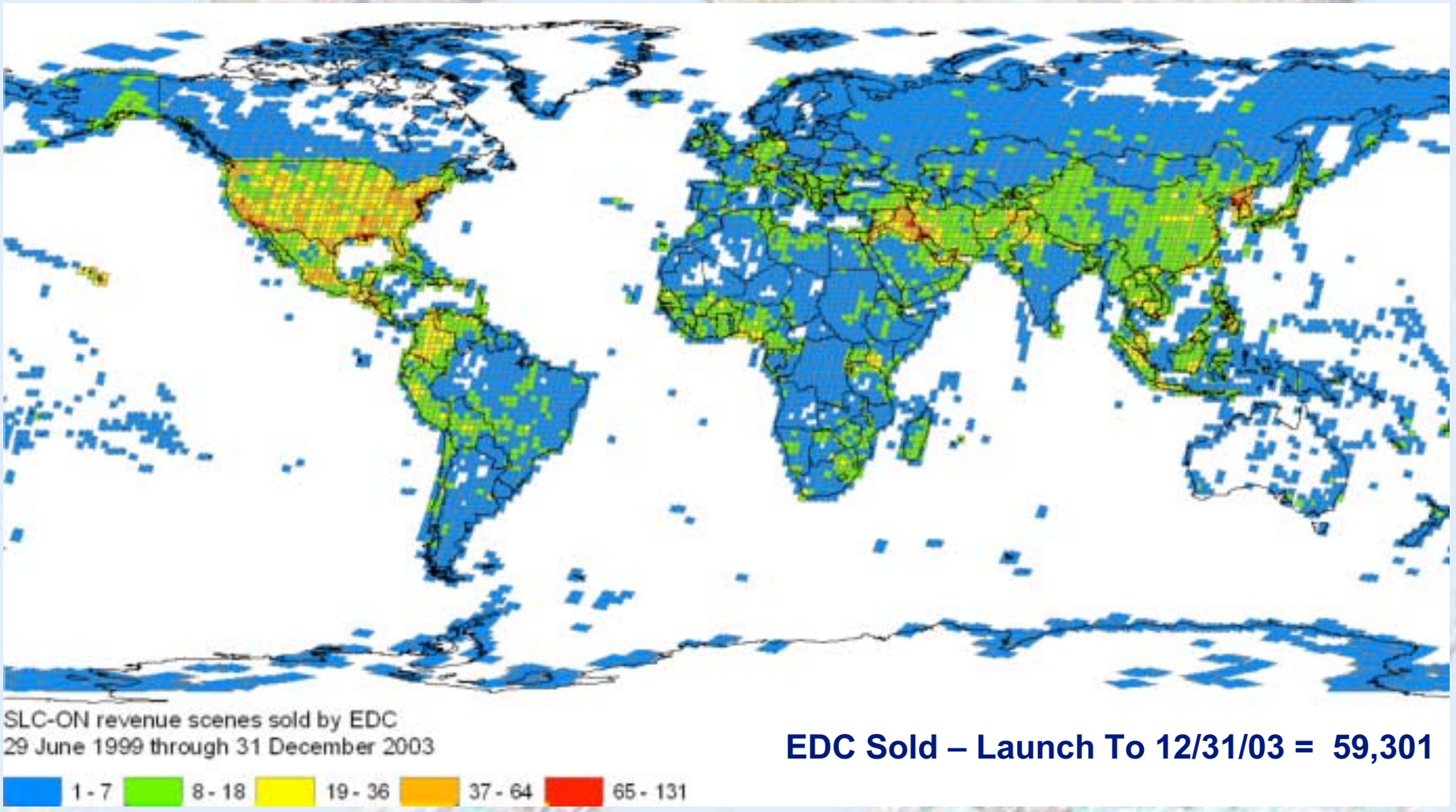


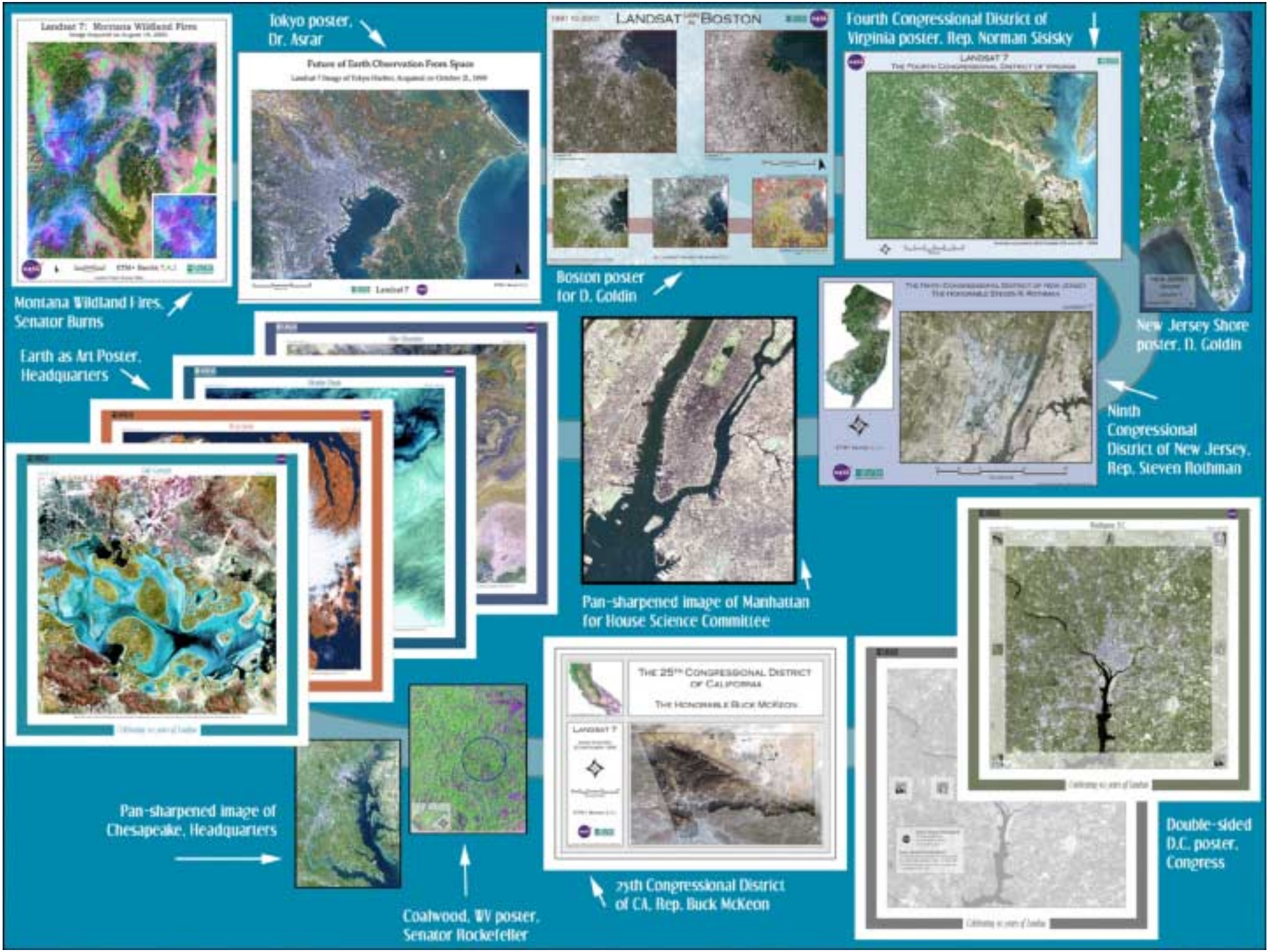
ETM+ Data Archived at EDC

Launch through Sept. 30, 2003 = > 342,000 scenes



Purchases per Path/Row from USGS Archive from 6/29/99 to 12/31/03 = > 59,300 scenes

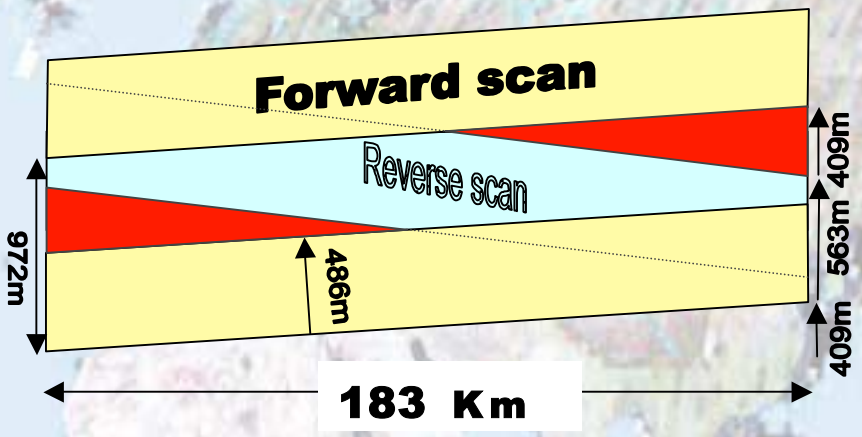



Landsat 7: Montana Wildland Fires
Montana Wildland Fires, Senator Burns
Tokyo poster, Dr. Asrar
Future of Earth Observation From Space
Landsat 7
LANDSAT BOSTON
Boston poster for D. Goldin
Fourth Congressional District of Virginia poster, Rep. Norman Sisisky
LANDSAT 7
New Jersey Shore poster, D. Goldin
Earth as Art Poster, Headquarters
Pan-sharpened image of Manhattan for House Science Committee
Ninth Congressional District of New Jersey, Rep. Steven Rothman
Pan-sharpened image of Chesapeake, Headquarters
Coalwood, WV poster, Senator Rockefeller
THE 25TH CONGRESSIONAL DISTRICT OF CALIFORNIA
THE HONORABLE BUCK MCKEON
LANDSAT 7
25th Congressional District of CA, Rep. Buck McKeon
Double-sided D.C. poster, Congress

The Landsat-7 Benchmark

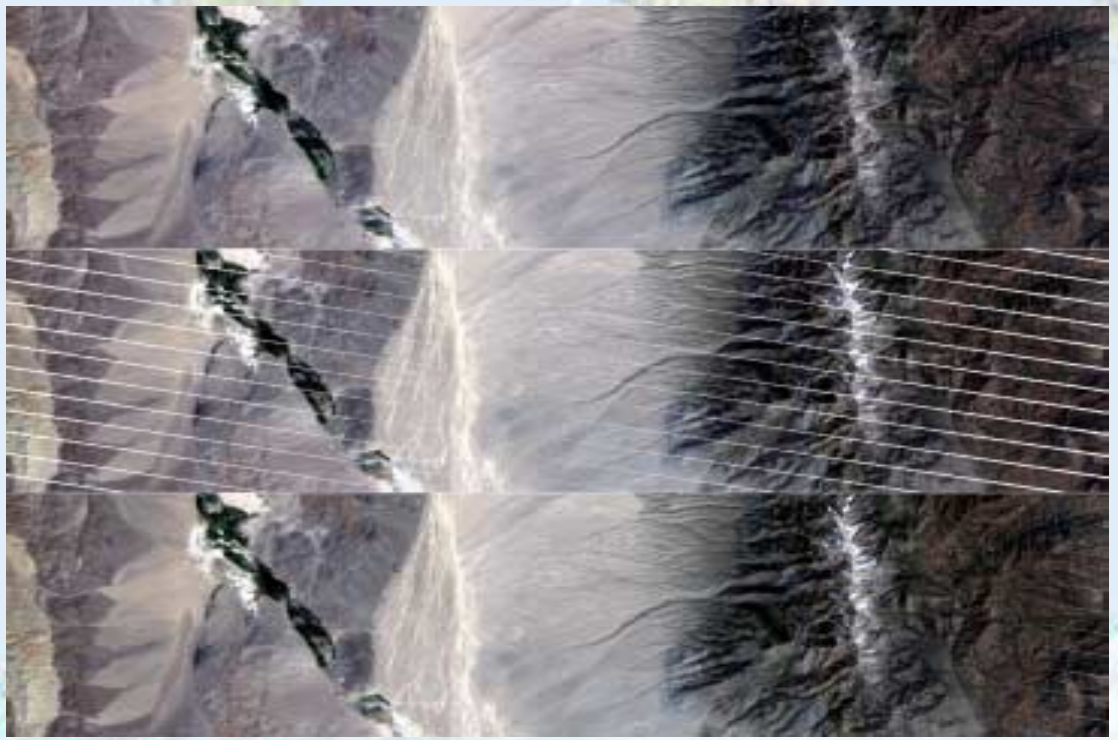
- **Landsat 7 has established an important benchmark for its successor mission with respect to:**
  - **Sensor and system performance, characterization, and calibration**
    - **On-orbit characterization and calibration over mission life**
  - **Mission operations and data acquisition**
    - **Archive-driven, systematic, substantially cloud-free, global coverage on seasonal basis**
  - **Data archival and data product distribution**
    - **- USGS archive provides non-discriminatory access**
    - **- Data products are available in consistent formats on consistent media**
    - **- Secondary distribution is unrestricted**

ETM+ scan pattern with & without SLC



Red regions are areas of non-coverage in full scene without SLC.

~78% of the real estate in a normal image is acquired with no SLC



With SLC

No SLC

No SLC, but with interpolation

Actions Being Taken

- We have teamed with USGS EDC to develop, test and implement algorithms that will provide useful ETM+ image products from data acquired after the SLC failure.
- The team has focused on two types of gap-fill products: in Phase 1, we fill in the missing data by using a normal scene acquired about one year prior to the impaired scene, and in Phase 2, we will use multiple SLC-off scenes acquired 16 – 32 days before and/or after a particular scene of interest in order to fill in the gaps of missing data.
- Phase 1 products are targeted for release by June 1, 2004, while Phase 2 products are targeted for release in early 2005.

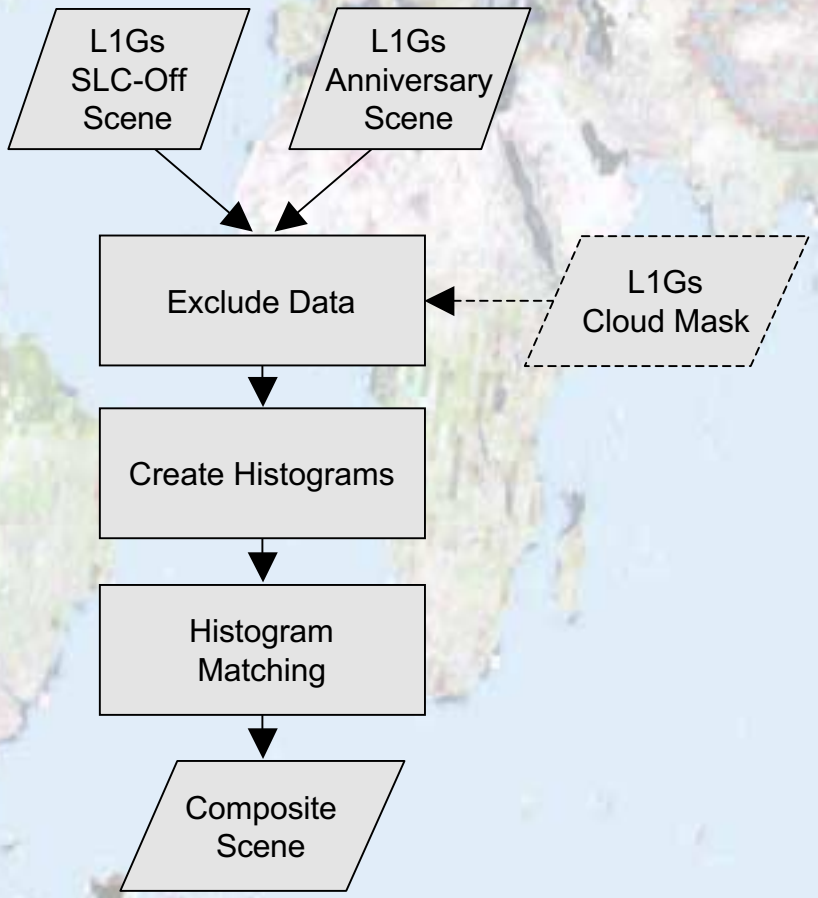
Recent Progress

- **Reviewed ~45 journal articles on image normalization techniques.**

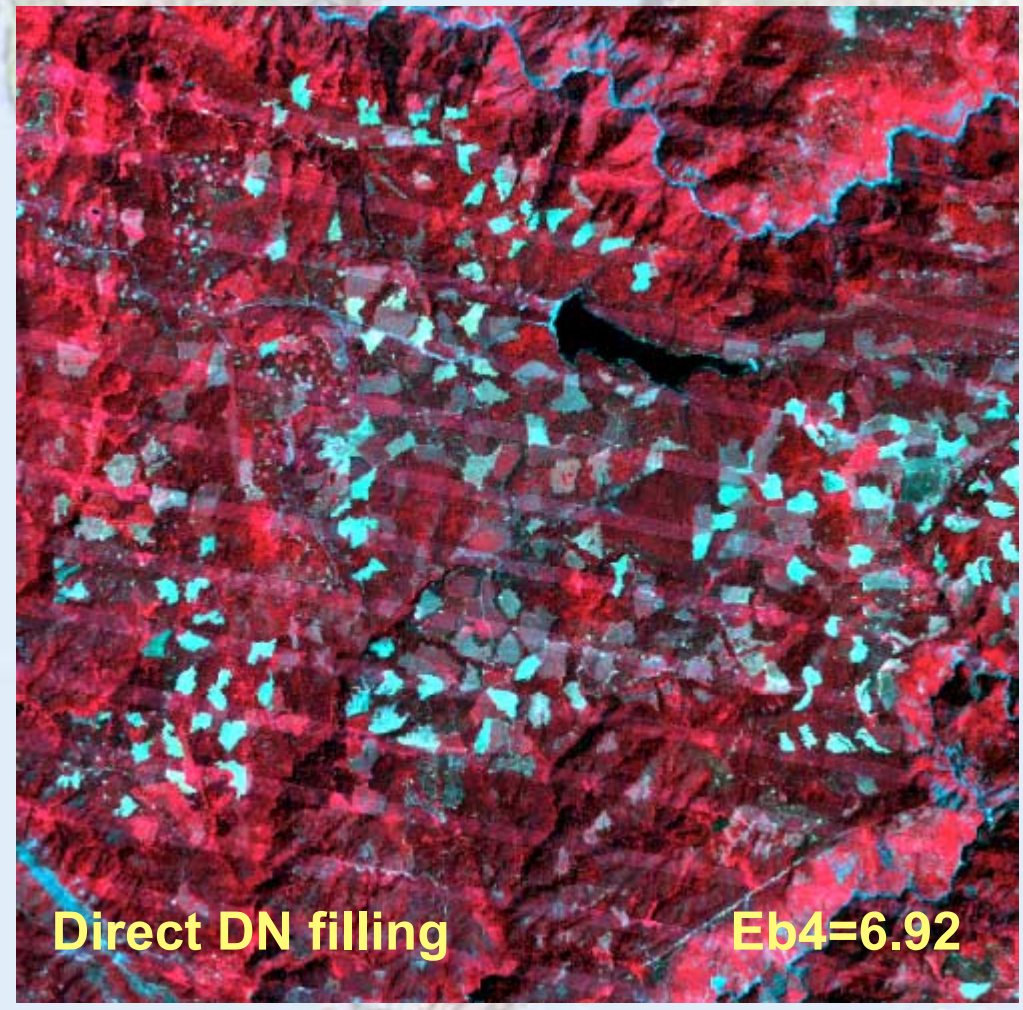
- **Four methods selected for further prototyping at GSFC…**
  - **CCRS Iterative Normalization (Du et al., 2001, 2002)**
  - **Hall et al. (1991) Radiometric Rectification**
  - **Regression Trees**
  - **EDC Local Histogram Matching algorithm**

- **End product will be a complete, gap-filled composite image very similar in characteristics to 8-day MODIS or AVHRR cloud-free composite products**
  - **creation of a cloud-free annual growing season composite image is a very realistic goal.**

Histogram Matching



Lake Tahoe: Region 1 ("Easy case")



Forest and clearcuts

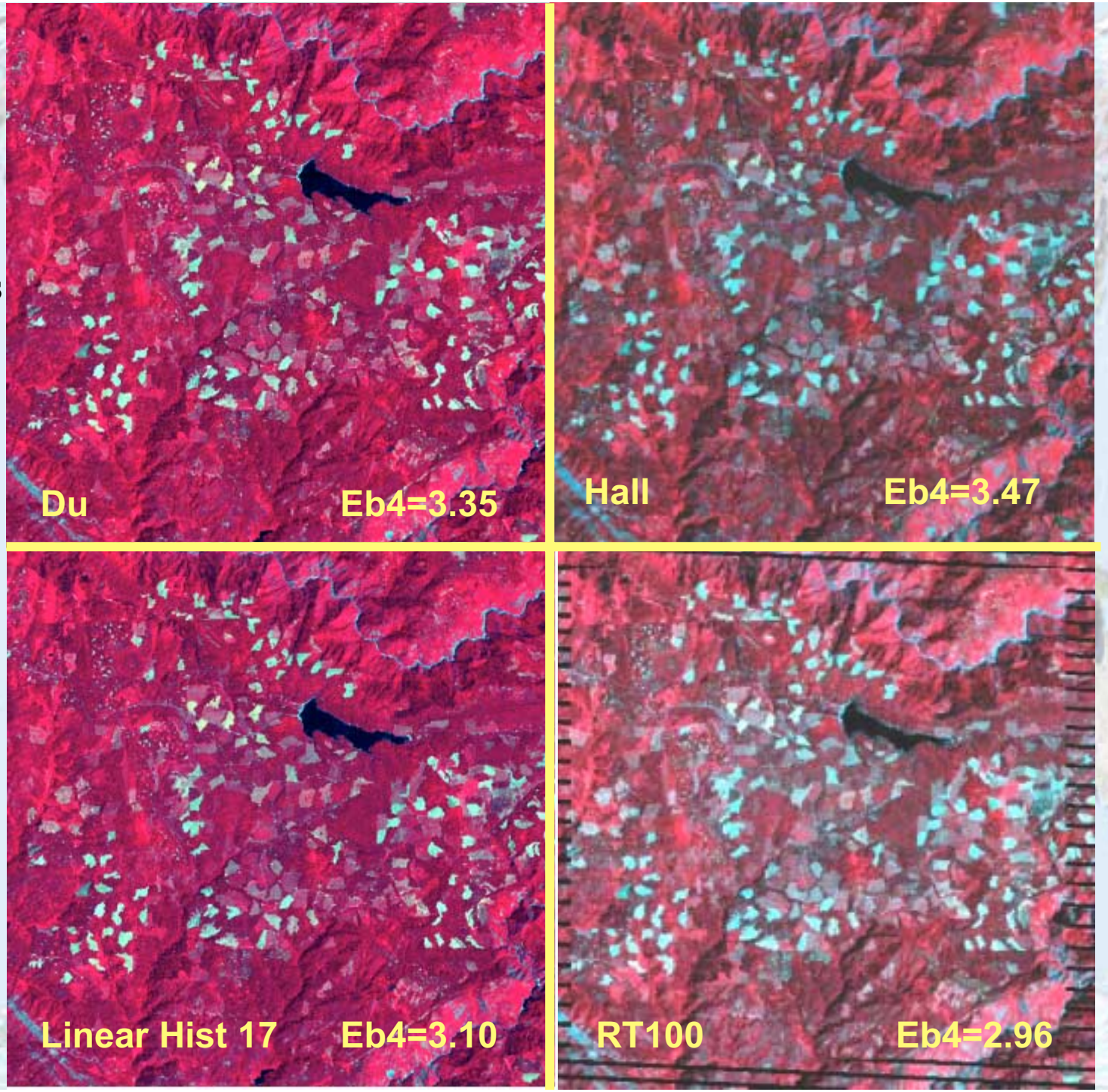
Image 1: 6/19/01
Image 2: 7/21/01

No attempt here to seamlessly blend data -- direct DN filling was applied.

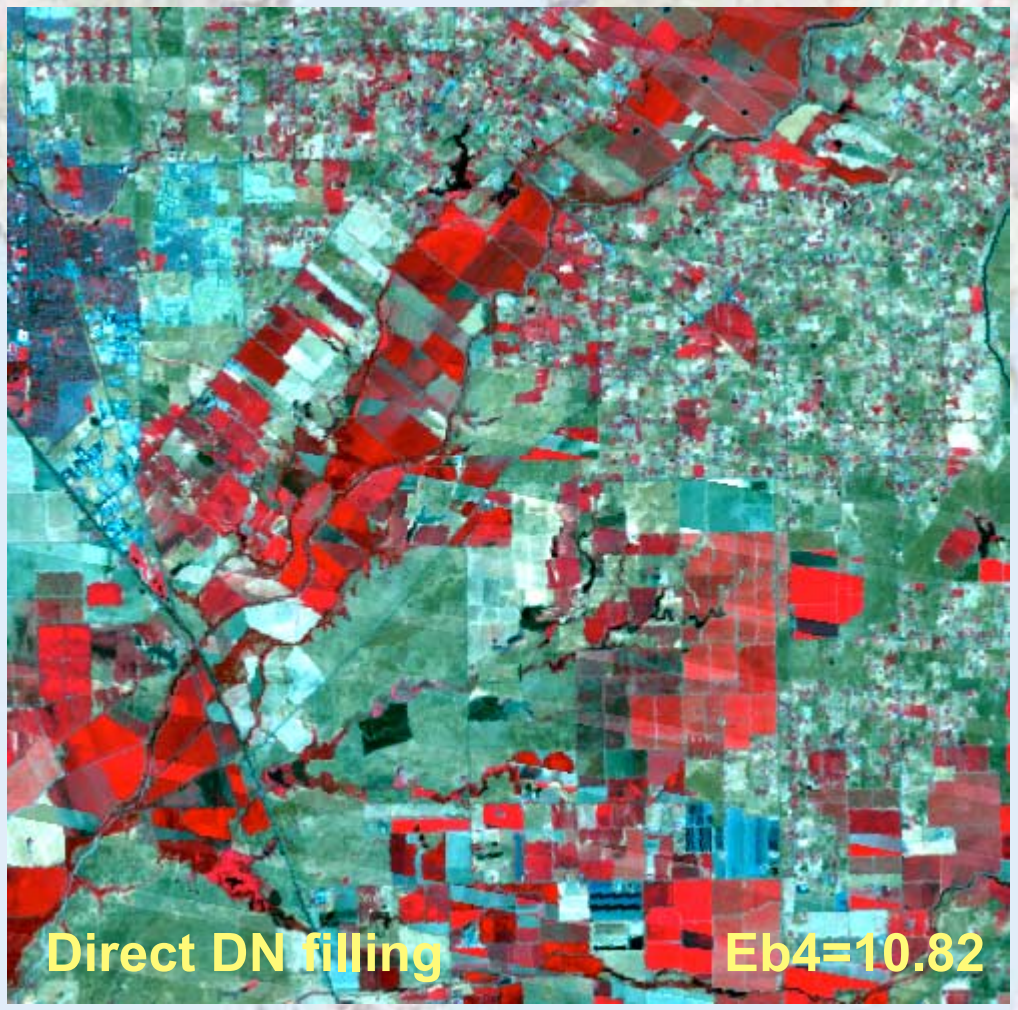
See enhanced examples on next page.

Differences in magenta color balance is not due to algorithm;

the prototypes were imple-mented in different image processing packages and the outputs were not normalized for this presentation

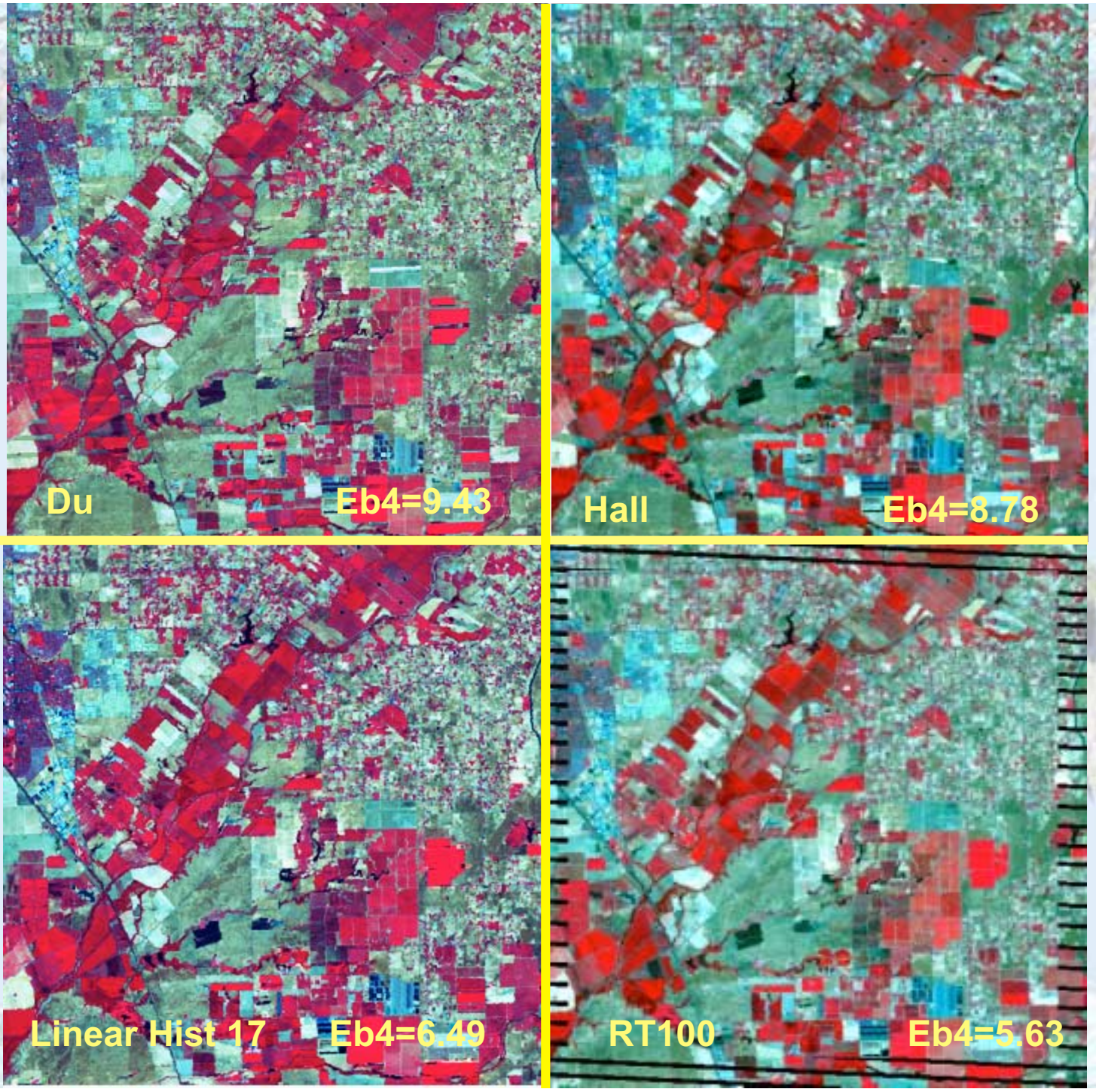


Lake Tahoe: Region 3 ("Hard case")



Mixed agriculture and urban

Image 1: 6/19/01
Image 2: 7/21/01


Du
Eb4=9.43
Hall
Eb4=8.78
Linear Hist 17
Eb4=6.49
RT100
Eb4=5.63

Concluding Thoughts

The Landsat-7 ETM+ system continues to produce high quality data of the Earth's land areas. To fulfill the expectations of the user community for full coverage single scenes, data from multiple acquisitions will be merged to resolve the SLC-off data gaps. The one system factor that most seriously suffers from the Landsat-7 SLC loss is the apparent reduction in temporal repeat coverage as it now takes two or more acquisitions to produce one complete view. For many users this loss of temporal repeat coverage may not be noticeable because their needs are generally met by one clear view per season. However, for users such as agricultural analysts, this loss of temporal coverage is a serious problem, that can only be addressed in the short run with Landsat-5 as long as it lasts. The only really effective longer-term answer for all users is the implementation of a robust Landsat-type Earth observation program that would include the launch of a new Landsat-type observatory as soon as possible.